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Diffuse X-rays scattering studies of Si self ion implantation

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Beamline(s): X16A

Introduction: In the frame of investigations on the defects produced in self-ion implanted Si, diffuse X-rays scattering measurements were performed. X-rays diffuse scattering is a powerful tool for the investigation of very small defects close to the surface. The evolution of the defects induced by the implantation was systematically measured during controlled annealing. The studies were performed in the UHV chamber at beamline X-16A.

Methods and Materials: The investigated samples are p-doped Si(111). Before irradiation, they were annealed at 1000°C followed by HF etching in order to release the surface stress and to remove the oxide layer. Afterward the samples were irradiated with Si ions using three different energies (50keV, 100keV and 150keV), in order to have a flat defect distribution throughout the irradiated zone. The samples were irradiated to doses from 0.5 to $6x10^{15}$ Si^{+}/cm^{2}. Diffuse X-ray measurements were systematically recorded through the in-situ annealing from room temperature to 1000°C.

Results and Conclusions: Figure 1 (a) shows the evolution of the DXS Huang scattering intensity, Iq^2, as a function of the scattering vector q during systematic annealing from room temperature to 800°C. The heights and relative positions of the peaks indicate changes in the defect morphology and size. In order to better visualize the process, figure 1 (b) shows the average intensity Iq^2 as a function of the annealing temperature. The intensity clearly decreases first followed by a rapid increase around 700°C. Finally the signal joins the background level after the total annealing of the defects around 1000°C.

The decrease of the scattering intensity from RT to 500◦C can be explained by the annealing of the small interstitial and vacancy clusters. The remaining defects after 500◦C are thought to be interstitial clusters. The clustering continues as the sample was annealed to higher temperatures and induces the increase in scattering intensity. The defects will finally anneal totally at 1000◦C.

This experiment shows the evolution of self-ion implantation defects in Si with the annealing temperature. The initial defects are very small and difficult to measure. Therefore diffuse X-rays studies can help to provide a better understanding of the initial states of the implantation.

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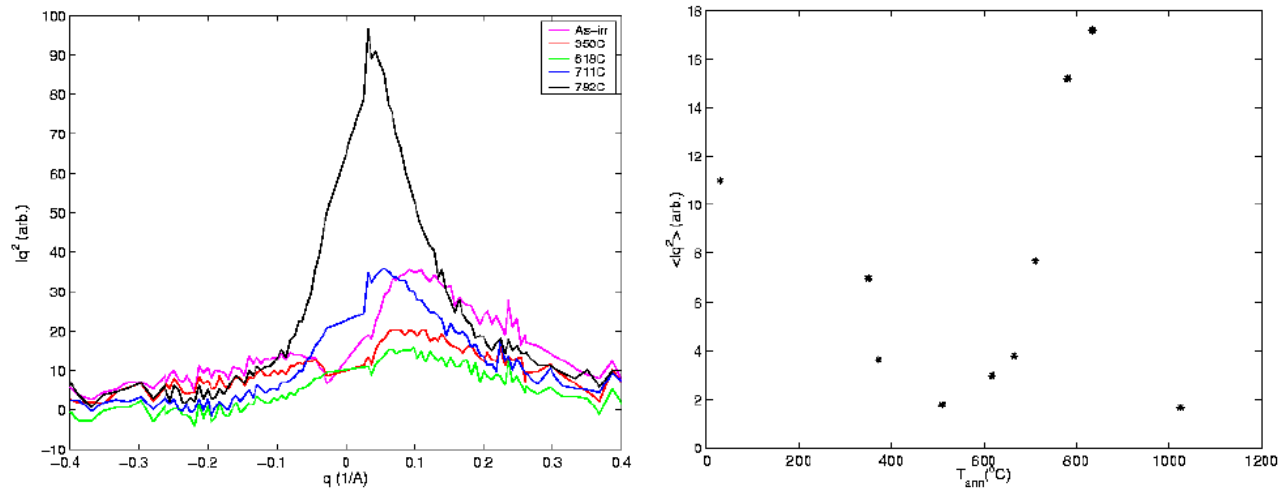

Figure 1: (a) DXS intensity Iq^2 as a function of the scattering vector q, measured after some selected annealing steps. (b) Iq^2 as a function of the annealing temperature. Iq^2 is obtained by subtracting the thermal background from the measured intensity. The irradiation dose is $3x10^{15}$ Si^{+}/cm^{2}.